

# **Comparative Study and Simulation of Boost Converter and Buck Converter for a Photovoltaic System**

**A THESIS IN PARTIAL FULFILMENTS OF REQUIREMENTS  
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**Signature of Student:**

## **Certificate**

This thesis on '**Comparative Study and Simulation of Boost Converter and Buck Converter for a Photovoltaic System**' required for partial fulfillment of B.Tech Electrical Engineering is written by myself under able guidance of **Dr. M. Pattnaik.**

**Signature of Student:**

**Roll No.**

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**Date:**

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### **Abstract**

Think about distinctive renewable energies, particularly sun powered vitality, conveyance of sun based radiation. The nitty gritty working as to the PV cell has been made natural. The configuration of support converter, the interfacing of the PV show alongside the converter has been secured. Yield of the converter is changed and the change in the information voltage and present into the support converter is checked. The current situation of sun oriented force, definitions and essential wordings have been secured. Working hypotheses have been comprehended and numerical representation for current and Fermi vitality have been found. Nitty gritty investigation of waveforms and circuit dissection and working of both boost and buck converter and its utilization for PV show has been carried out and compared also.

Most of the world's energy sources originated from tried and conventional sources-fossil fills, for example, coal, regular gasses and oil. These powers are frequently term non-renewable energy sources. However, the accessible measure of these powers are to a great degree huge, yet because of diminishing in level of fossil fuel and oil level step by step after a couple of years it will end. Thus renewable energy source interest builds as it is ecological inviting and contamination free which decreases the harmful impact on environment as in case of fossil fuel based energy.



# CHAPTER I

## 1.1. INTRODUCION:

The late upsurge in the interest of PV frameworks is because of the way that they deliver electric force without hampering the earth by specifically changing over the sun powered radiation into electric force. However the sun oriented radiation never stays consistent. It continues shifting for the duration of the day. The need of great importance is to convey a consistent voltage to the framework regardless of the variety in temperatures and sun based insolation. PV clusters utilized with help converters might be a response to that. Support converters might be utilized to make a consistent ventures up DC voltage. [5], [6], [8]

In spite of the fact that the exchange of the demonstrating of PV cluster utilizing a support converter will remain our principle point, we will likewise administer the current situation and patterns of sun oriented vitality in India and around the globe. A thorough study and understanding of the working of a sunlight based cell and support converter will be carried out. A Simulink model utilizing MATLAB codes for scientific interpretations of created current and voltage will be carried out. Reenactments for different levels of radiation and waveforms for circuit utilizing help converter will be shown. Hypothetical perspectives will be overall investigated and point of interest dissection will be carried out to further edify the subject. [7], [11]

## 1.2. MOTIVATION:

The Conventional wellsprings of vitality are quickly exhausting. Also the expense of vitality is climbing and along these lines photovoltaic framework is a guaranteeing option. They are rich, contamination free, appropriated all through the earth and recyclable. The obstacle component is its high establishment cost and low transformation proficiency. Hence our point is to build the productivity and force yield of the framework. It is additionally obliged that consistent voltage be supplied to the heap independent of the variety in sun oriented irradiance and temperature. PV shows comprise of parallel and arrangement blend of PV cells that are utilized to create electrical force relying on the climatic conditions (e.g. sun oriented light and temperature). So it is important to couple the PV cluster with a converter.[4]

### **1.3. WORK SUMMARY:**

The objective of the project was to find a solution to the power and voltage fluctuations in the PV systems. The work done here includes modelling of PV array and interfacing it with both boost and buck converter. We have tried to find which converter works best for the PV array and gives optimum performance. Various literature work on the subject has been done and understood and comprehensive modelling based on Simulink has been done pertaining to this theoretical knowledge.

### **1.4. SOLAR ENERGY:**

Sun powered vitality, a non-ordinary kind of vitality. Sun powered vitality has been utilized by human race since long times utilizing a heaps of innovations. Sun oriented radiation and optional sun powered fueled asset like tidal and wind power, hydroelectric and biomass, are in charge of a large portion of the promptly accessible non-expected sorts of energies on earth. Just a little divide of the trappable sunlight based vitality is utilized. [3], [4]

Sun oriented fueled power era relies on upon photovoltaic setup alongside hotness motors. Sunlight based vitality's provision are huge and imaginative speculation is required to unleash undiscovered requisition of sun powered cell. To produce sun based vitality, common path is to utilize photograph voltaic exhibits which get vitality from sun and converts it to electrical vitality. Heavenly bodies are partitioned into either aloof sun powered or dynamic sun oriented which relies on upon the way they trap, change over and appropriate sunlight based vitality. [5], [7]

### **1.5. PHOTOVOLTAIC CELL:**

Sun based cells are built by semiconductor material, usually silicon based. For PV cells, a more slender semiconductor sheet is uniquely made to structure an electric field, positive extremity on one side and negative on other. At the point when photons strike a sun powered cell, electrons are accumulated detached from the semiconductor material. In the event that current conduits are appended to the both the sides, structuring a current exchanging circuit, the electrons move to manifestation of a current i.e., power for fulfilling different power needs. [5], [11]

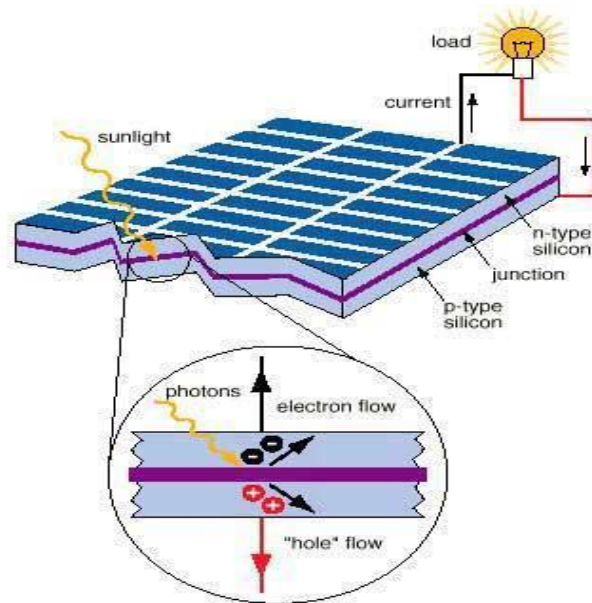


Fig 1.5.1 : Photovoltaic Cell [5]

## 1.6. MATERIALS USED IN A PV CELL:

The materials used in PV cells are as follows:

### a) **Single-crystal silicon**

Single-gem silicon cells are the most widely recognized in the PV business. The primary method for delivering single-precious stone silicon pertaining to the Czochralski strategy. High-immaculateness polycrystalline is dissolved in quartz pot. A solitary gem silicon seed is dunked into this liquid heap of polycrystalline. The seed is brought out gradually from the molten liquid, a solitary precious stone ingot is shaped. The ingots are cut into slim wafers something like two hundred micrometers thick. The slight wafers then cleaned, covered, and amassed into modules and shows [7].

### b) **Polycrystalline silicon**

Comprising of little grains of single-gem silicon, polycrystalline PV cells are less vitality effective than single-crystalline silicon PV cells. The grain limits in polycrystalline silicon block the stream of electrons and lessen the force yield of the cell. A typical methodology to deliver polycrystalline silicon PV cells is to cut dainty wafers from pieces of cast polycrystalline [7].

## Chapter II

### 2.1 MODELLING OF A SOLAR CELL:

A sunlight based cell is the key working unit of a daylight based board. A photovoltaic display is surrounded by making a relationship of various PV cells in course of action and parallel. Considering simply a lone PV cell; it could be shown by using a current source, a diode and resistors. This model is the single diode model of PV cell. Two diode models are similarly used however simply single diode model is considered. [1],[2]

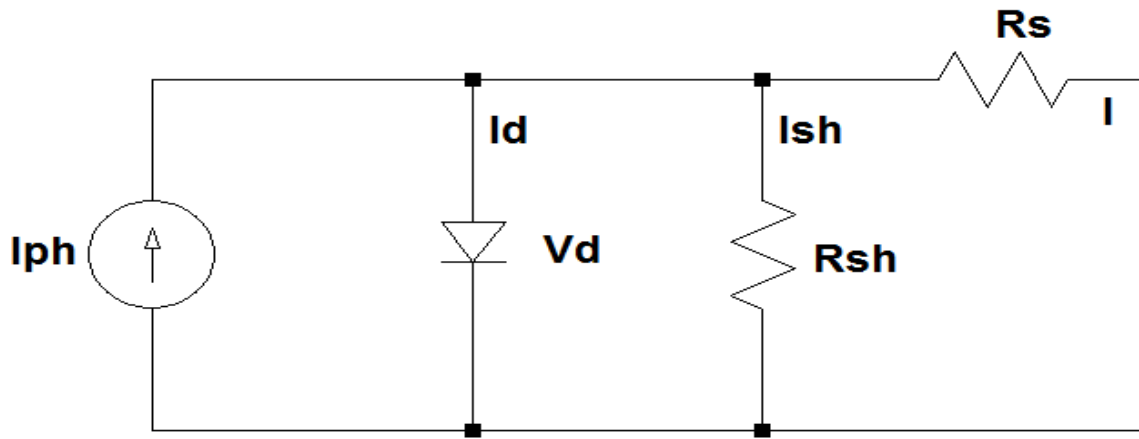


Fig 2.1: Single diode model of a solar cell

The characteristic equation for a photovoltaic cell is given by,

$$I_{ph} = I_{scr} + k_i(T - 298) * \eta \quad (2.1)$$

$k$ : Boltzmann's constant,  $1.38 * 10^{-23}$  J/K;

$q$ : Electron charge,  $1.6 * 10^{-19}$  C;

$K_i$ : Short circuit current temperature coefficient at  $I_{scr}$ ;

$\Lambda$ : Solar irradiation in  $W/m^2$ ;

$I_{scr}$ : Short circuit current at 25 degree Celsius;

$I_{ph}$ : Light-generated current;

$E_{go}$  : Band gap for silicon;

$T_r$  : Reference temperature;

$I_{or}$  : Cell saturation current at  $T_r$ ;

$R_{sh}$  : Shunt resistance;

$R_s$  : Series resistance;

The trademark articulation of a PV module relies on number of cells in parallel and number of cells in series in the arrangement. It is inspected from comes about that the variety in present is not as much subject to the parallel resistance and is reliant on the series resistance [2]

$$I = N_p * I_{ph} - N_p * I_o * \left( e^{q * \frac{V_{pv} + I_{pv} R_s}{N_s A K T}} - 1 \right) \quad (2.2)$$

I-V and P-V curves for a solar cell are shown in the following figure. It can be seen that the cell operates as a constant current source at lesser values of operating voltages and a constant voltage source at lesser values of input current.

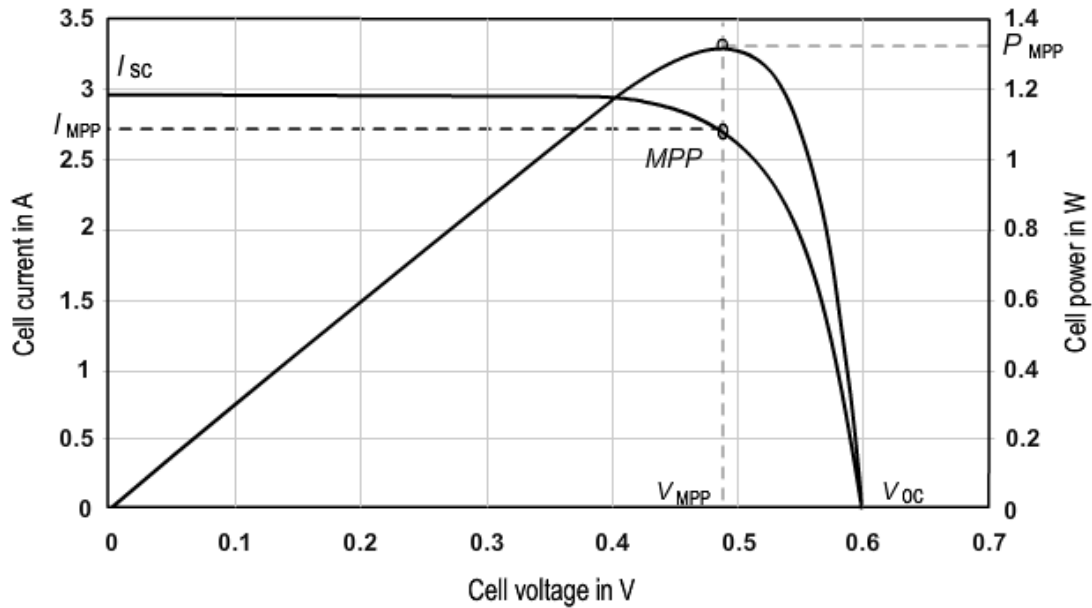


Fig 2.2: P-V I-V curve of a solar cell at given temperature and solar irradiation

## 2.2. SIMULATION RESULTS OF PV ARRAY:

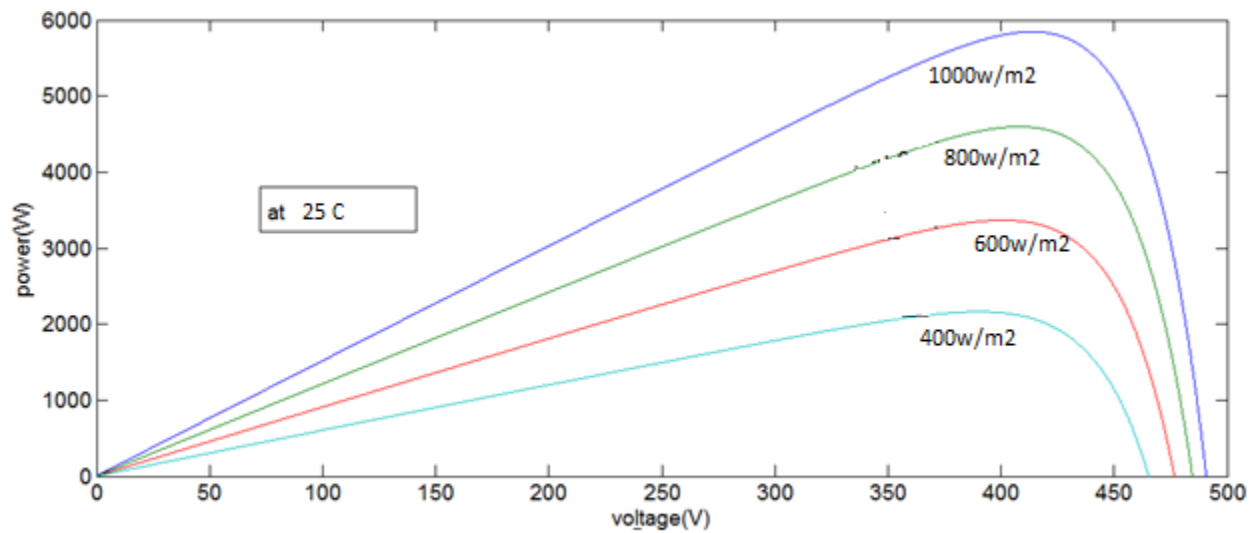


Fig 2.2: Variation of P-V curve with solar irradiation

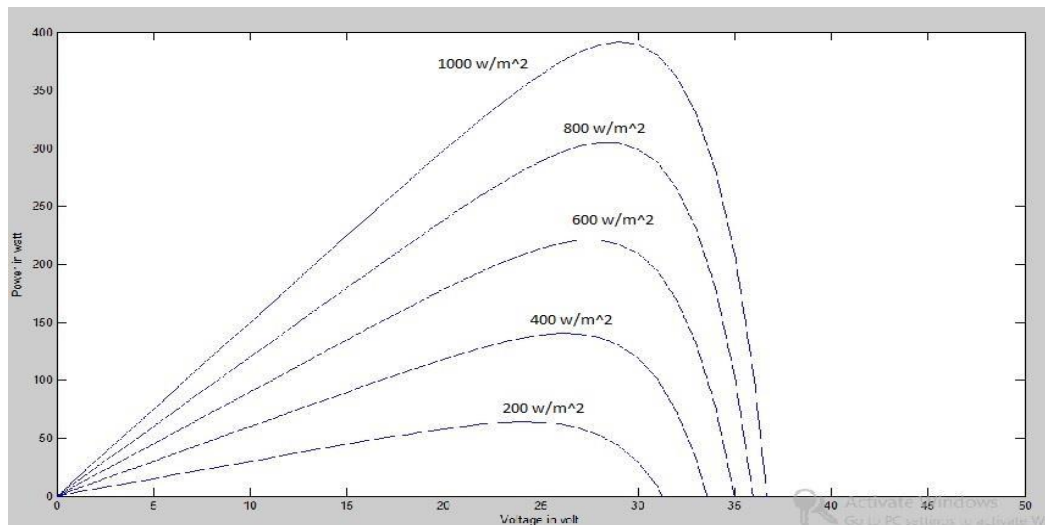


Fig 2.3: Power vs Voltage with variable irradiance

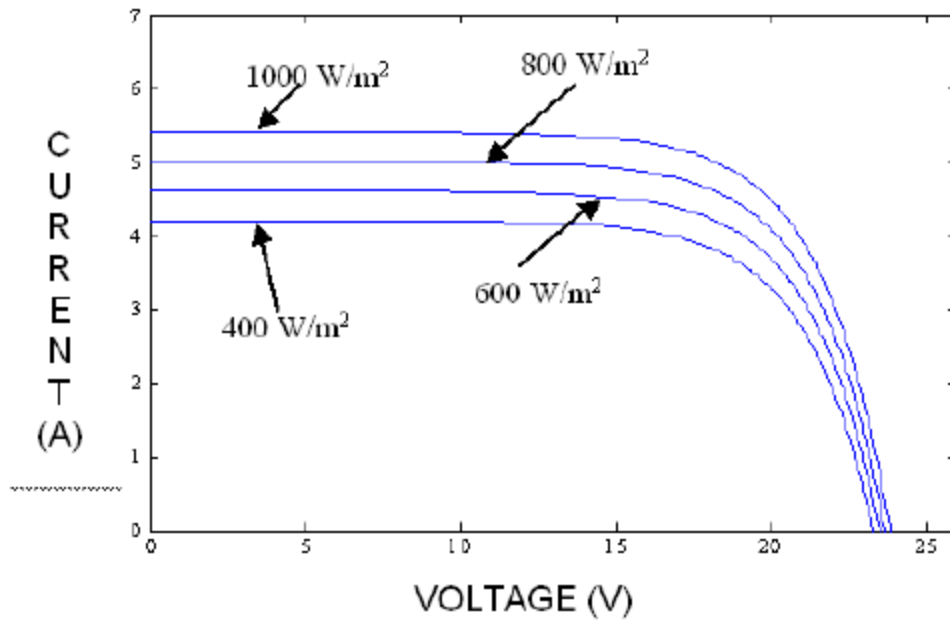


Fig 2.4 Current Vs Voltage with variable Irradiance

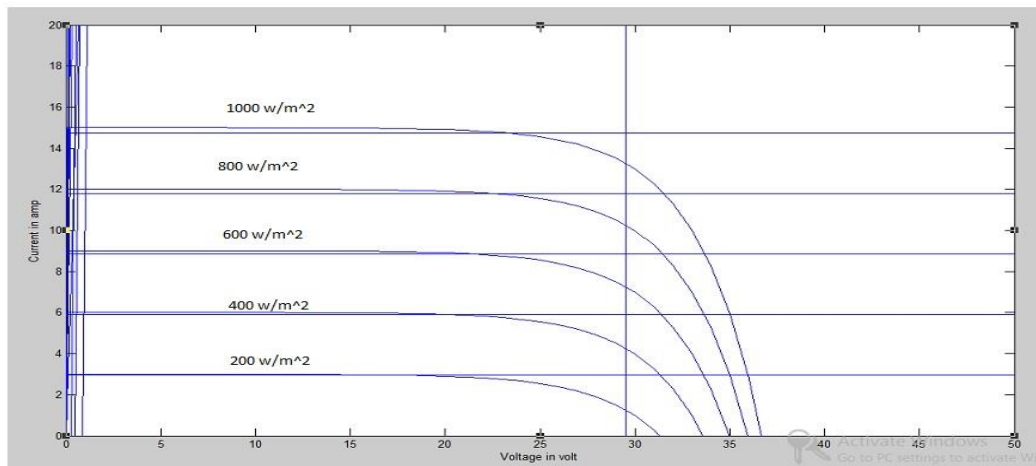


Fig 2.5: Current vs Voltage

### 2.3. MATLAB CODE OF PV ARRAY:

```
T=27;
Tr0=75; % Reference temperature in degree Fahrenheit
Tr=((Tr0-32)*9/5)+273; % Reference temperature in
kelvin S=[1000 800 600 400 200]; % Solar radiation in
mW/sq.cm
%S=60;
ki=0.00023; % in A/K
Isc=3.75; % SC Current at ref. temp. in
A Irr=0.000021; % in A
k=1.38065*10^(-23); % Boltzmann
constant q=1.6022*10^(-19); % charge of
an electron A=2.15;
Eg0
=1.166;
alpha=0.47
3;
beta=636;
Eg=Eg0-(alpha*T*T)/(T+beta)*q; % band gap energy of semiconductor
used pv cell in joules
Np=4;
Ns=60;
V0=[0:1:400
]; for i=1:5
Ipv=(Isc+ki*(T-Tr))*((S(i))/100);
Ios=Irr*((T/Tr)^3)*exp(q*Eg/(k*A))*((1/Tr)-
(1/T)); I0=Np*Ipv-
Np*Ios*(exp(q/(k*T*A)*V0./Ns)-1);
P0 = V0*I0;
plot(V0,I0); axis([0 50
0 20]); xlabel('Voltage
in volt');
ylabel('Current in
amp'); hold on;
plot(V0,P0); axis([0
50 0 400]);
xlabel('Voltage in
volt'); ylabel('Power in
watt'); hold on;
plot(I0,P0);
axis([0 20 0 400]);
xlabel('Current in
amp'); ylabel('Power
in watt'); hold on;
```



## **2.4. METHODS FOR MAXIMUM POWER POINT TRACKING:**

The following two methods used most for MPPT are given below:

- Perturb and Observe Controller
- Incremental Conductance Controller

### **1. Perturb and Observe method:**

This strategy is exceptionally normal. In this systems few number of sensors are utilized. Examples of the working voltage is taken and the calculation shifts the working voltage as coordinated and specimen's  $dp/dv$ . On the off chance that  $dp/dv$  is sure, then the calculation increases the voltage esteem towards the MPP till  $dp/dv$  is negative. This cycle will proceed till the calculation achieves the most extreme force. This calculation is not adapted for managing progressions of the sun based light at high values. The voltage really never achieves a faultless esteem however sways around the MPP.[12]

### **2. Incremental Conductance method:**

This technique utilizes the sun powered show's incremental conductance to assess the indication determines that that the greatest force point is accomplished and along these lines it stops and furnishes a proportional payback benefit of working voltage for most extreme force point. This technique checks for rapidly changing light conditions more exactly than P&O. Only weakness of this strategy is that it's use of numerous sensors for working and henceforth is monetarily less effective. [12]

Differentiating w.r.t voltage gives;

$$\frac{dP}{dV} = I + V \frac{dI}{dV} \quad (2.3)$$

When the maximum power point is reached the slope  $dP/dV = 0$ .

## 2.5. FLOWCHARTS OF MPPT ALGORITHMS:

### 2.5.1. Flowchart for P&O Method:

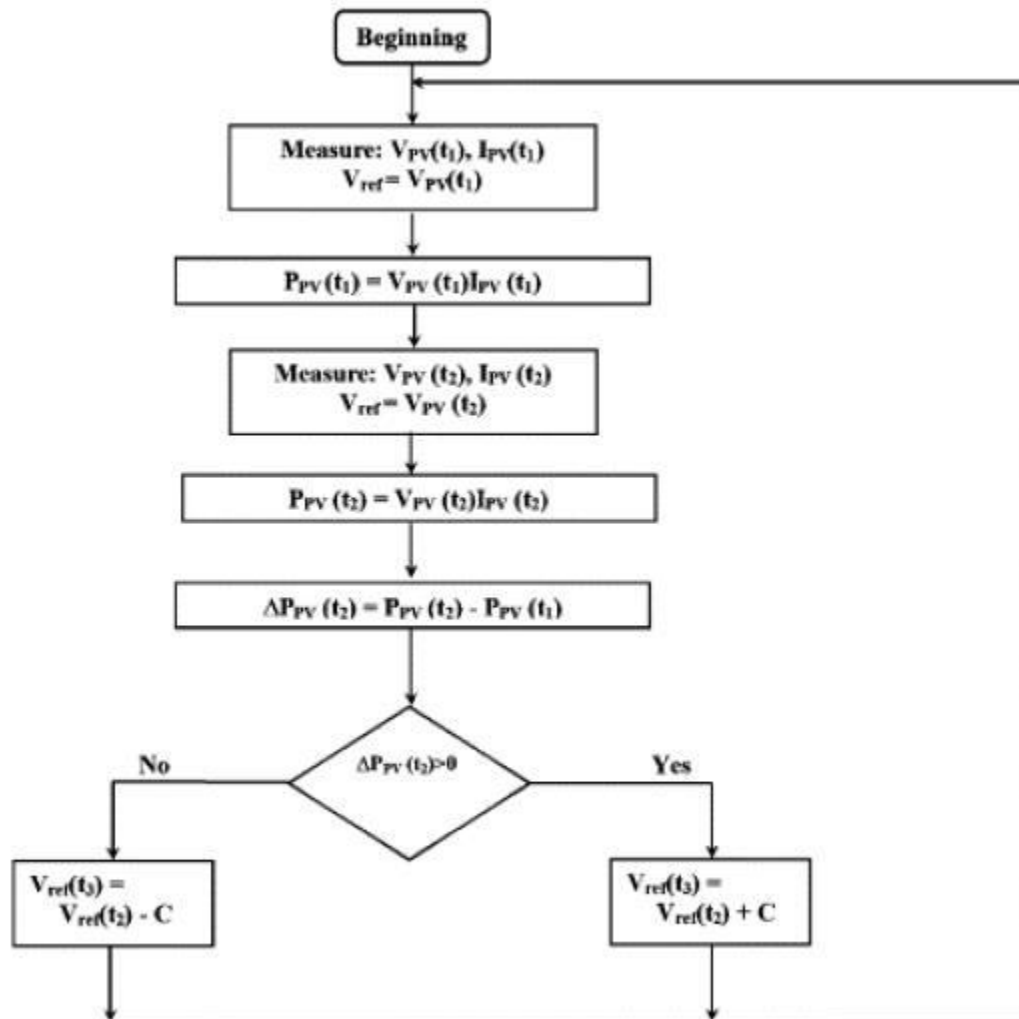


Fig 2.6: Flowchart for P&O method.

2.5.2. **Flowchart For Incremental Conductance Method:**

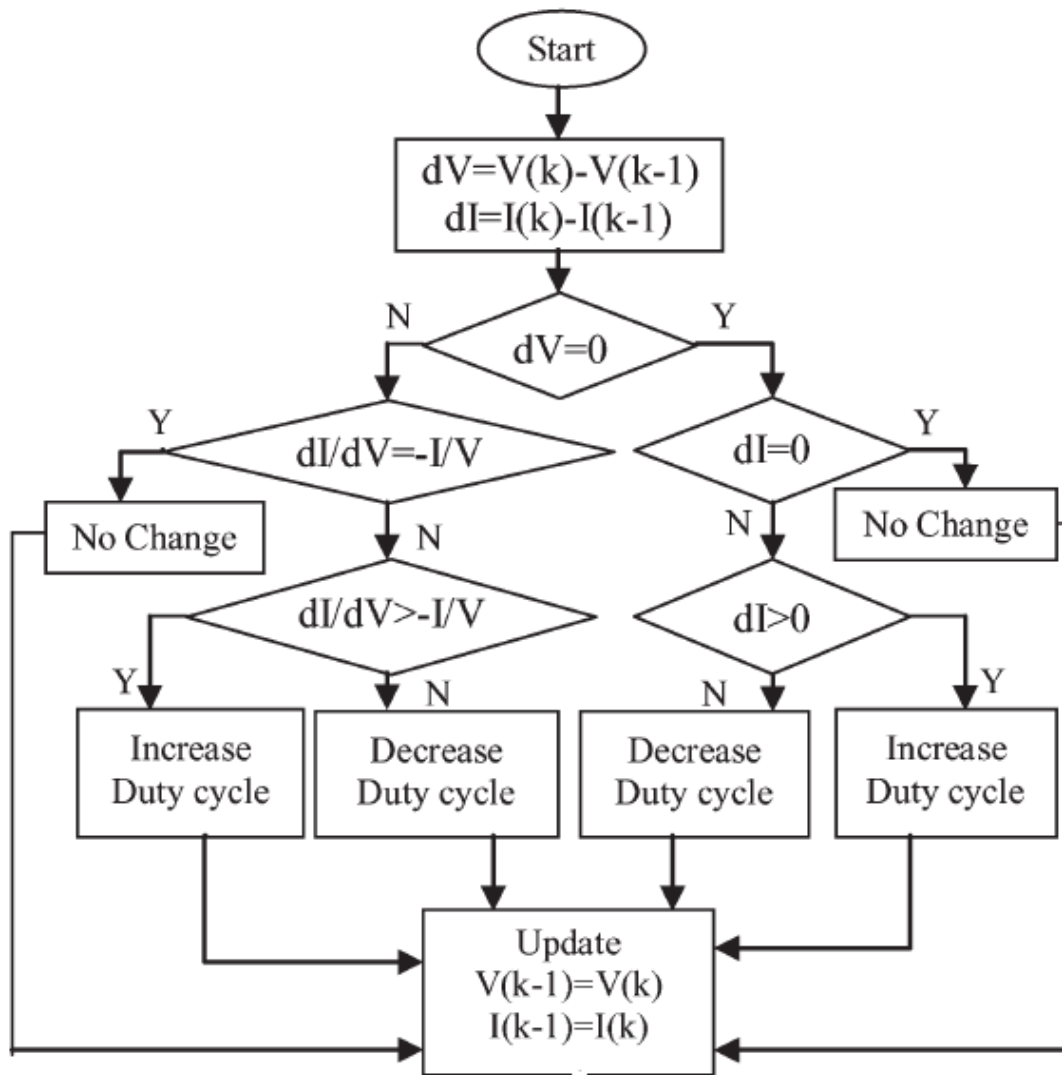


Fig 2.7: Flowchart for P&O method.

## CHAPTER III

### 3.1. BOOST CONVERTER:

#### 3.1.1. Working Theory:

A boost converter or a voltage stepped up converter is a DC-DC converter with yield voltage enhanced contrasted with enter. It is sort of exchanged mode power supplied or SMPS that holds at any rate a diode and a transistor and in any event a vitality putting away component like capacitor, inductor, or the two together. Channels developed utilizing capacitors which in some cases are utilized within synthesis with inductors have been added to converter yield to lessen yield voltage swell. [12]

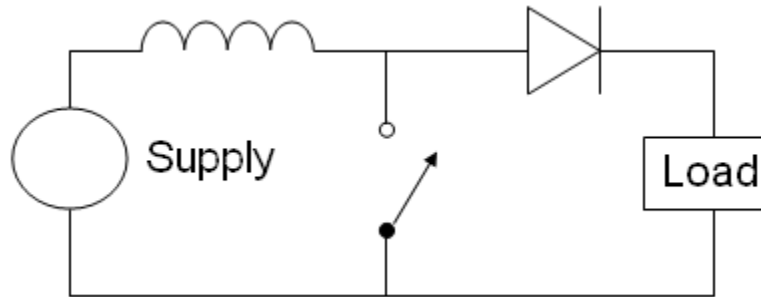


Fig 3.1: Boost Converter Schematics

#### 3.1.2. Circuit Analysis:

The important standard that works the boost converter has been the propensity of the inductor to oppose variations in present by making and pulverizing an attractive field. In this converter, the yield voltage is constantly greater than the voltage inputted. A circuit of boost force stage is demonstrated.

(a) If switch is shut, electric current courses from the inductor in direction of clock is course and the inductor acts a store to some vitality in producing an attractive field. Extremity in the lifter side of the inductor is sure.

(b) If switch is in open position, current shall be lessened due to higher impedance. The attractive field at one time made will be devastated to keep up current stream towards the heap. Subsequently the extremity would be switched (means inductor will have negative polarity on the side) subsequently sources would be in arrangement creating more voltage.

On an off chance that the switch is cycled quick enough, the inductor won't release completely in the middle of charge stages, the heap would dependably have a voltage more prominent than pertaining to only the source if the switch is open. Likewise if the switch is open, the capacitor parallel to the heap is charged to joined potential. At this point when the switch is shut and the right side is short circuited from left side, capacitor is subsequently fit in giving potential difference and vitality to the heap. Throughout this time, the blocker diode keeps the capacitor against releasing from the switch. The switch should obviously be opened and quickly to keep the capacitor to release excessively. [9], [12]

The fundamental guideline of boost converter comprises of two unique states. The On-state, in which the switch is shut, bringing about an expand in the current through inductor. Switch is non- conducting in off state and the main way leading to current in inductor from the diode, and capacitor and the heap. This leads to exchanging of the vitality amassed in the capacitor. Throughout the switching on state.

### 3.2. **Buck Converter:**

The fundamental operation of the buck converter has the current being controlled in inductor controlled by switches, two in number. The ideal converter, the segments are taken to be ideal. Particularly, the switch and the diode deal with zero voltage dropping when in on state and no current stream when in off and the inductor has no series resistance. Furthermore, it is accepted that data and yield voltages don't vary throughout the span of a cycle (this would infer the yield capacitance as being limitless). [14]

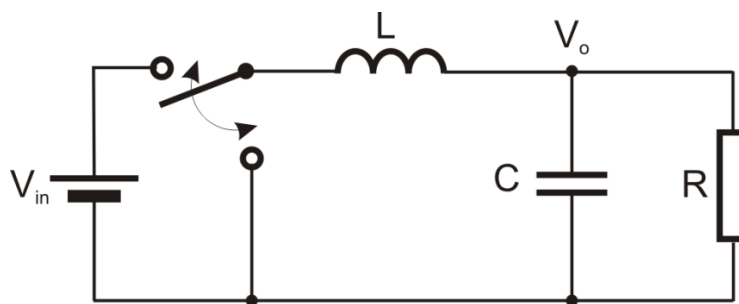


Fig 3.2: Buck Converter Schematics

At the point when the switch is initially shut, the current will start to expand, and the inductor will deliver a restricting voltage over its terminals in light of the evolving current. This voltage drop checks the voltage of the source and thusly diminishes the net voltage over the heap. About whether, the rate of progress of current reductions, and the voltage over the inductor likewise then abatements, expanding the voltage at the heap. Throughout this time, the inductor is putting away vitality as an attractive field. On the off chance that the switch is opened while the current is as of now changing, then there will dependably be a voltage drop over the inductor, so the net voltage at the heap will dependably be short of what the data voltage source.[14],[16]

At the point when the switch is opened once more, the voltage source will be expelled from the circuit, and the current will diminish. The changing current will deliver a change in voltage over the inductor, now supporting the source voltage. The put away vitality in the inductor's field.

### **3.2.2. Modes Of Operation:**

#### **1. Continuous Mode:-**

This converter works in nonstop mode if the current flowing from the inductor never tumbles to null throughout the commutation. At the point when the switch as shown above in previous page is shut. The current flowing from the inductor climbs straightly. As the diode is converse predisposition by the source voltage  $V$ , no current courses from it. [14]

At the point when the switch is off, the diode is biased in forward direction.

#### **2. Discontinuous Mode:-**

In some circumstances, the measure of energy needed is excessively little. For this situation, the current flowing from the inductor tumbles to nothing throughout a piece of time period. The main distinction in the standard depicted is that inductor is totally released at the ending of commutation. This has, be that as it may, some impact on the past mathematical statements.

If converter works in relentless state, the energy in the inductor is the same at the start and at ending of the cycle (on account of intermittent mode, it is zero). This implies that the normal estimation is zero for inductor voltage. [10], [14]

## CHAPTER IV

### 4.1. SIMULATION FOR MPPT:

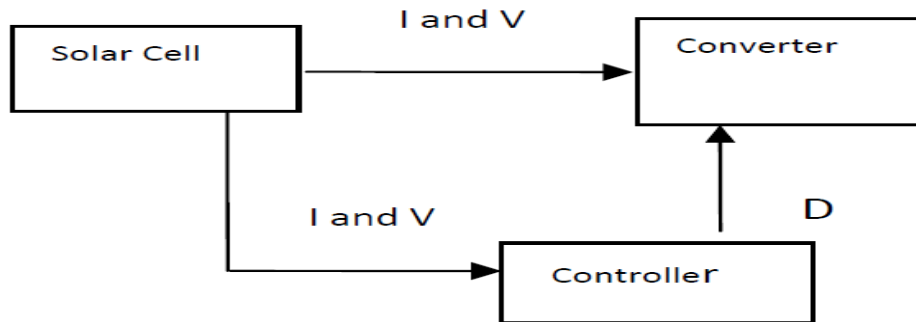


Fig 4.1: Block Diagram of solar interfaced with MPPT algorithm

### 4.2. SIMULATION OF SOLAR MODULE:

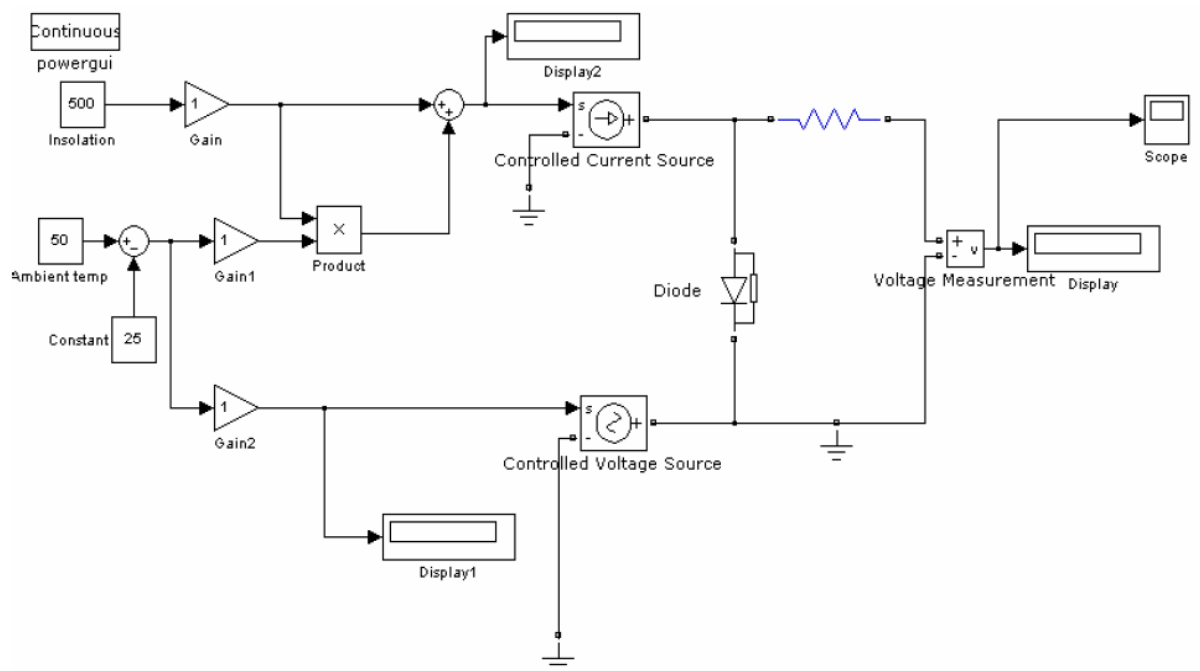


Fig 4.2: Simulink model for PV module

#### 4.3. BOOST CONVERTER SIMULINK MODEL:

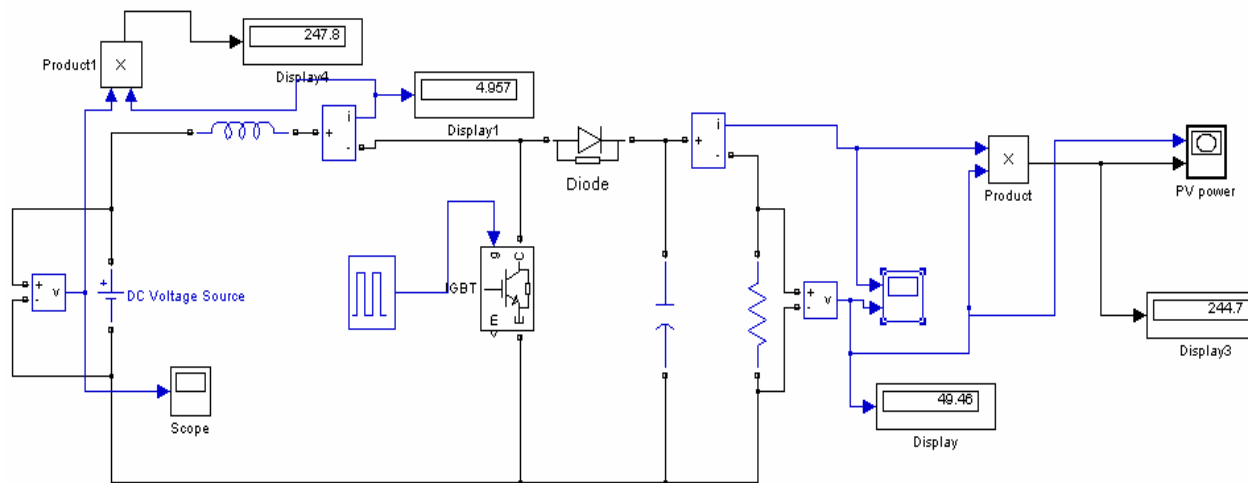


Fig 4.3: Boost converter Simulink model

#### 4.4. BUCK CONVERTER SIMULINK MODEL:

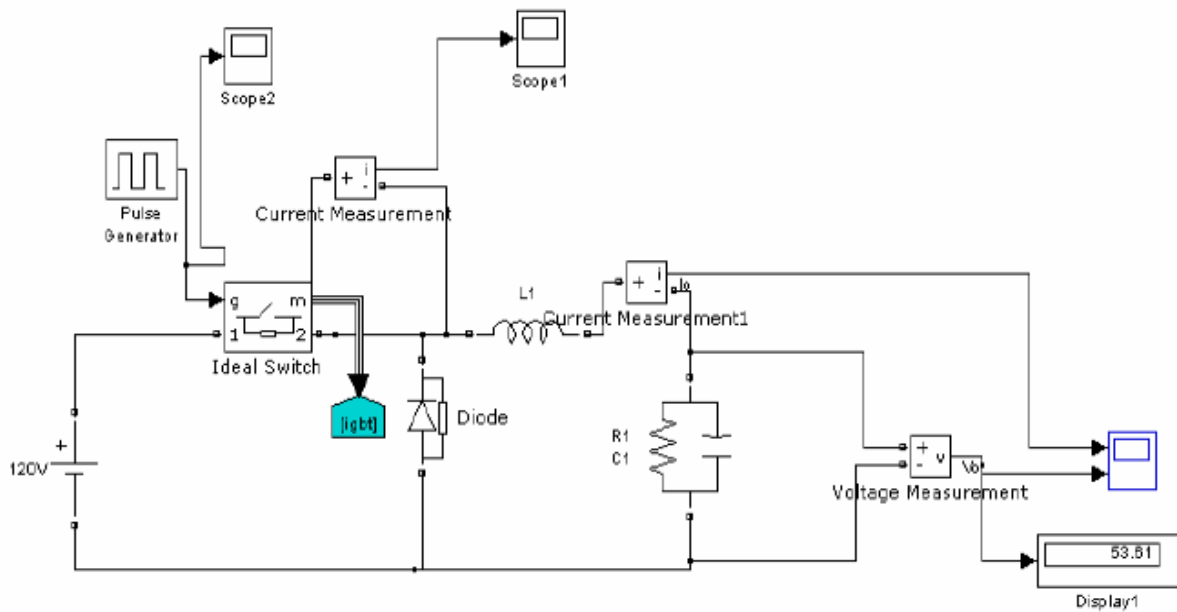


Fig 4.4: Buck Converter Simulink Model



#### 4.5. SIMULINK MODEL FOR MPPT TECHNIQUES:

**(a) Simulink Model for P&O:**

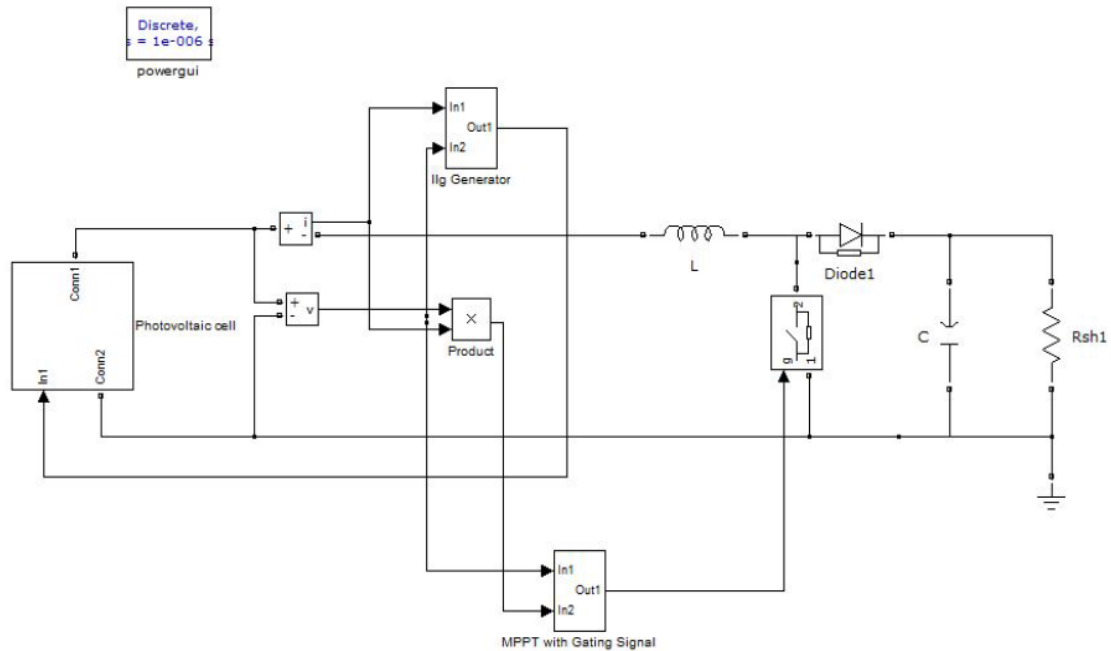


Fig 4.5: Model for P&O method

**(b) Simulink Model for ICM:**

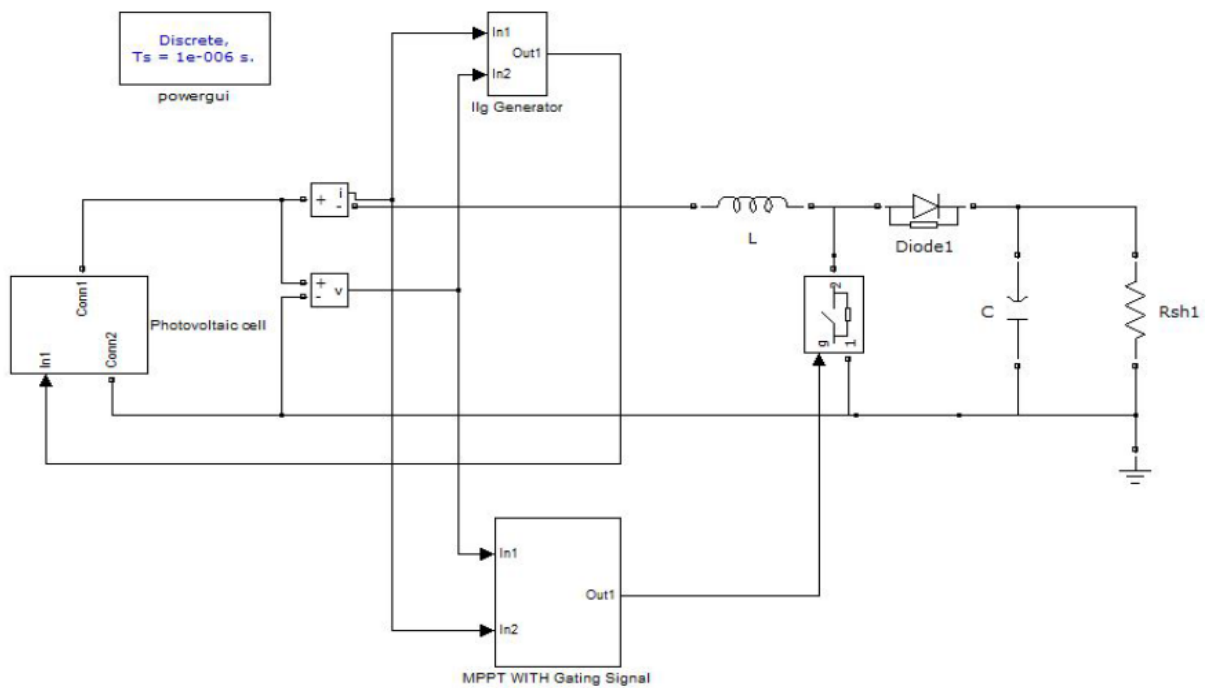


Fig 4.6: Model for Incremental Conductance Method.

#### **4.6. RESULTS OF SIMULATIONS:**

##### **4.6.1 Comparison of Boost and Buck Converter:**

The tables below gives us a better insight regarding the importance of Maximum Power Point Tracking algorithm. Clearly the algorithms used boost the power produced by the photovoltaic array. Table 5.2.1 shows that boost converter is a step up converter and buck a step down one. Table 5.2.2 is based on incremental conductance method using boost converter. Results for others have been compared in subsequent page.

Converter	V <sub>in</sub> (V)	V <sub>out</sub> (V)
Boost	12	21.6
Buck	12	5.2

Table 4.1: Boost and Buck Converter individual results

##### **4.6.2 Comparing Power output:**

Irradiance (W/m <sup>2</sup> )	Power with no MPPT (W)	Power with MPPT (W)
400	19.5	42.8
600	40.5	58.2
800	71.2	92.4

Table 4.2: ICM used, boost converter interfaced power comparison

#### 4.6.3. Comparing P&O Method and ICM Results for Boost Converter:

Table 5.3, figure 5.7 and 5.8 demonstrate that input voltage for both controller is practically the same. P&O method gives a not steady condition. The voltage and current diminish quickly and in conclusion comes to the equal magnitude as at the beginning stage. The result demonstrates that method that associated with this converter gives a stabler yield is the incremental conductance method. P&O method can attain greatest yield esteem at 37.67 V that superior to incremental conductance controller.

MPPT Algorithm	$V_{PV}$ (V)	$V_{in}$ (V)	$V_{out}$ (V)	$I_{in}$ (A)	$I_{out}$ (A)
P&O	21.8	38.28	37.67	1.87	1.87
ICM	21.8	38.33	28.92	172.3	1.48

Table 4.3: P&O and ICM Results for Boost Converter

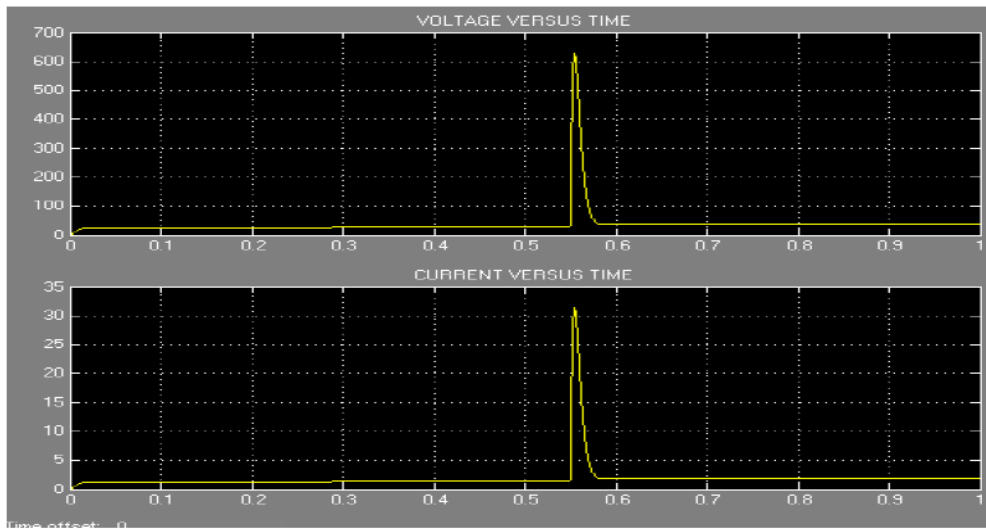


Fig 4.7 Simulation Results for P&O using Boost Converter

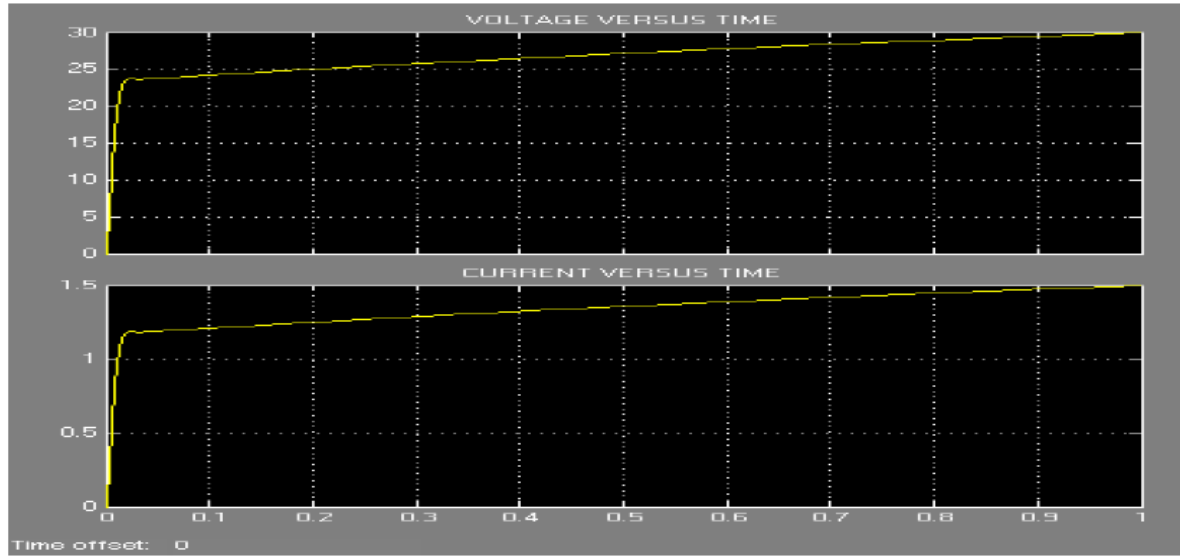


Fig 4.8: Simulation Result of ICM using Boost Converter

#### 4.6.4 Comparing P&O and ICM for Buck Converter:

Table 5.4 and figures 5.9 and 5.10 give better insight for buck converter interfacing. For Incremental Conductance method the yield current and voltage have not changed between output and input. The P&O method give a distinction for output and input esteem. The yield worth act as converter act. Potential difference falls down from 21.8V to 16.8V. Lastly the potential difference worth is 511 mV. This framework demonstrates that the incremental conductance method will work more nicely with this converter over P&O method. Incremental conductance method will give more stable results from beginning to ending.

MPPT Algorithm	$V_{PV}$ (V)	$V_{in}$ (V)	$V_{out}$ (V)	$I_{in}$ (A)	$I_{out}$ (A)
P&O	21.8	20.5	16.8	0.94	0.94
ICM	21.8	17.6	17.79	0.82	0.84

Table 4.4: P&O and ICM Results for Buck Converter

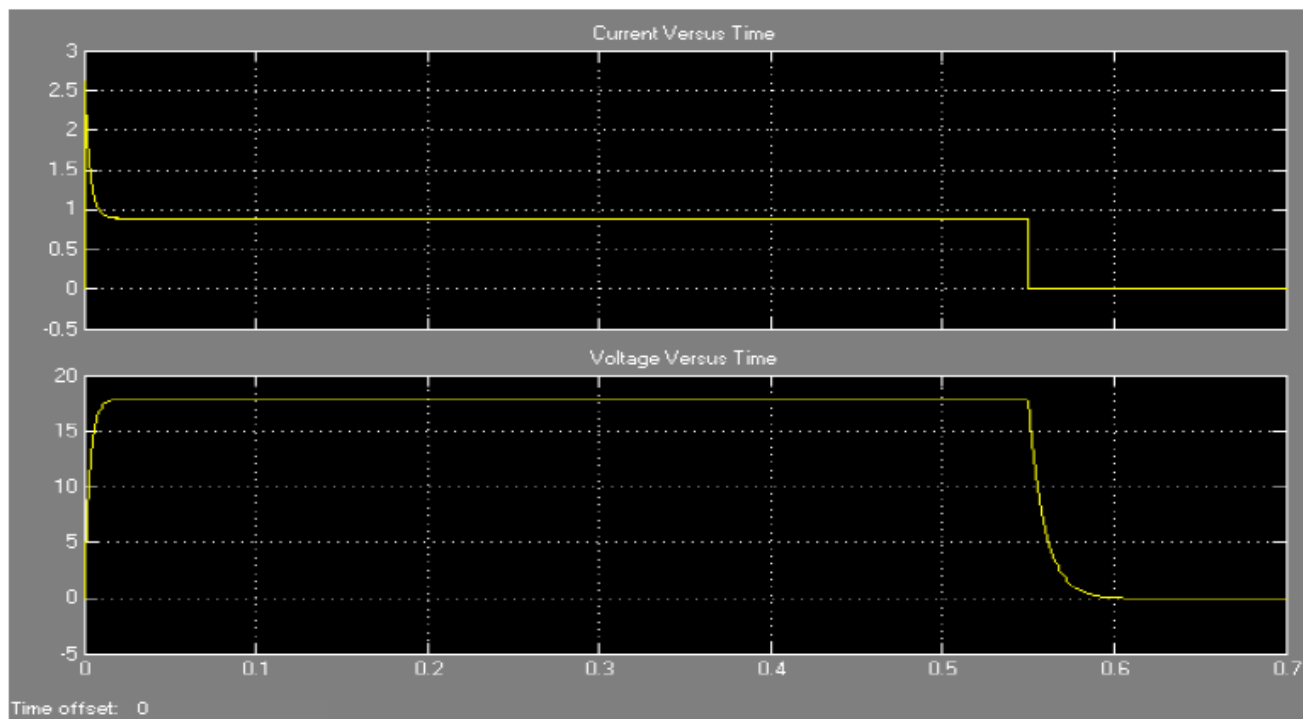


Fig 4.9: Simulation Result of P&O method using Buck converter

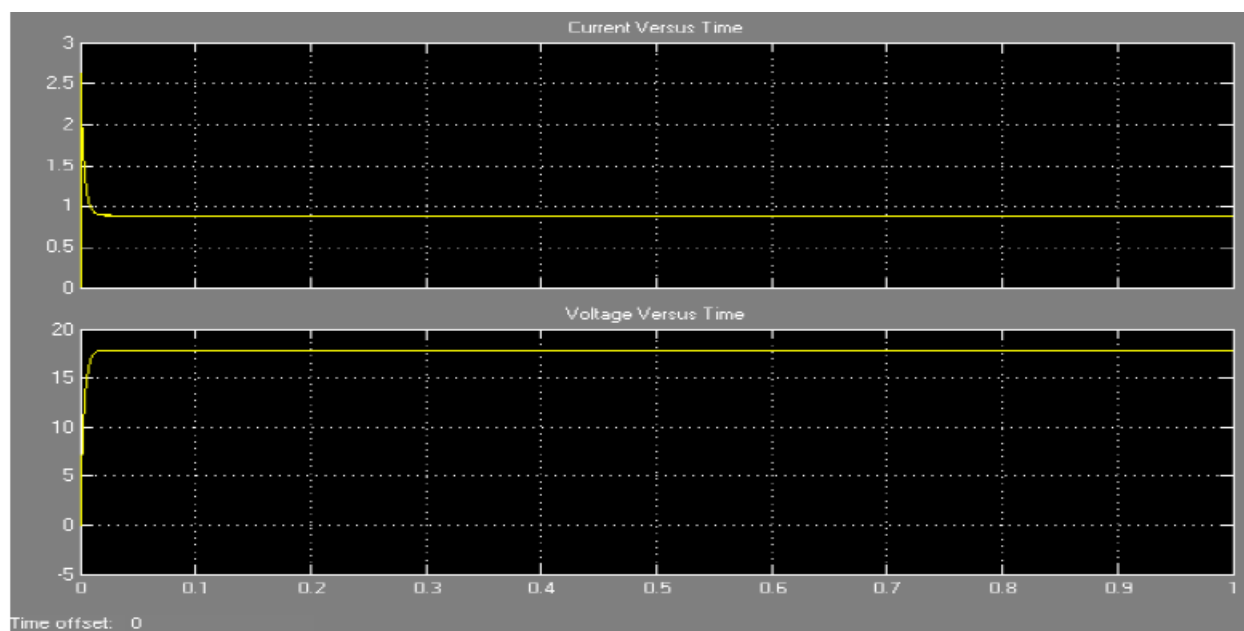


Fig 4.10: Simulation Result of IC method using Buck converter

## CHAPTER V

### 5.1. CONCLUSION:

The first phase of the project which includes basic research into solar energy scenario in India and around the world. Some new trends in effect for improved solar energy production have been discussed. The major drawback surrounding solar energy has been the low efficiency in solar cells. To improve the efficiency we have integrated the PV module with boost converter. The control of duty cycle in boost converter has helped in formulating basic MPPT techniques. Modelling of photovoltaic array has been done and analyzed. Various simulation results in accordance with varying irradiance have been found and checked based on theoretical learning. The model of boost converter is also done and analyzed. Few MPPT, Maximum Power Point Tracking, techniques have also been discussed. A special importance on perturb and observe method and incremental inductance method is being given.

This proposal has exhibited an examination of most prevalent of MPPT controllers, Perturb Observe method as well as Incremental Conductance method. This paper concentrate on examination of three distinctive converter which will joined with either controller. A straightforward sunlight based board that has normal estimation of temperature and irradiance has been incorporated in reenactment circuit. From all the cases, the most advantageous method for MPPT is incremental conductance method. This method gives a finer yield esteem for buck converter and support converter. Thus this method would give diverse sort of bends for the whole converter. In reproduction converter indicate the best execution the method works at the best situation utilizing buck controller.

### 5.2. FUTURE WORK:

Change to this undertaking might be made by following the greatest force point in changing ecological conditions. Natural change could be change in sun powered light or change in encompassing temperature or even both. This is possible by utilizing Simulink models to complete MPPT as opposed to thinking of it code in Embedded MATLAB capacities. In the Simulink models the sunlight based light and the temperature might be given as variable inputs rather than consistent values as done here. Another calculation called as DMPPT is ended up being extremely beneficial. It could be executed for better productivity in sun oriented cells.

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